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PAPERS AND DISCUSSIONS

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CHARACTERISTICS OF QUICKSAND AND OTHER SOILS MET IN ORDINARY EXCAVATION

By Colonel Chas. R. Gow *

(Presented before the Sanitary Section, December 5, 1923.)

In any discussion of the characteristics of a given soil we have to bear in mind that there are general characteristics which identify it wherever it may be found, but in addition there may also exist local peculiarities which are not necessarily general in their occurrence. For example, although the residual clays which are found in the southern states have many properties in common with the transported glacial clays of our northern section, they display marked variations in many respects, due to their differing origins and physical and chemical properties.

So far as I shall discuss local soil characteristics, such discussion will necessarily be confined very largely to this particular territory, — that is, the eastern section of Massachusetts, with which I am more especially familiar. On the other hand, the general characteristics which obtain hereabouts are fairly common for the entire northeastern section of the United States, because all of the soils now covering that area, *i.e.*, all of the earth soils, and some of the rocks as well, were deposited by similar agencies many centuries ago, when the continental glacier alternately advanced and retreated over Canada and the northeastern portion of our own country, lying east rly from the Mississippi River and southerly from the Canadian border to the states of New Jersey and Pennsylvania. Over that large area we deal almost exclusively with materials which have been transported to their present location as distinguished from soils found elsewhere throughout the country which are more or less of local origin.

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TYPES OF SOIL ENCOUNTERED

So far as soils are concerned, we are called upon to consider only gravels, sands and clays in this section of the country, because these materials constitute in general terms the soil variation in classification. As a matter of fact, gravel and sand are distinguished from each other chiefly with respect to the size of their particles. That is, under the microscope the most minute grain of sand becomes in reality a small boulder or pebble of exactly the same physical and chemical properties as those possessed by the larger product. It has simply been worn down to a small size through abrasion or weathering. When we come to the clays, however, we find a material which is easily distinguishable from the sands and gravel, although coming substantially from somewhat the same basic origin, — that is, from the decomposition of felspathic rocks. In the event that sand itself were to be decomposed in the same manner it would yield in large measure the material which we recognize as clay. Generally speaking, it can be said that the average particle of clay is approximately one-fiftieth the diameter of the average grain of sand, and such particles may have diameters as small as 1/25000 of an inch. Consequently they are distinguishable only under the most powerful microscope.

There are, of course, many gradations among the various soils. Mixtures of gravel and sand are frequently encountered, also coarse sands grading into the fine, and fine sand mixed with clay. It is, therefore, very difficult to draw a hard and fast line of demarcation between them. Generally speaking, the observable distinction between clay and fine sand is the greater plasticity of the former. Just what causes the quality of plasticity in clay has not, I believe, ever been satisfactorily determined. It was at one time suspected that there was some definite relation between plasticity and the alumina content, but it has recently been determined that the amount of alumina bears no particular relation to the quality of plasticity. In another theory it has been assumed that the particles of clay exist in the form of very thin wafers somewhat resembling sheets of mica, very minute in size, and that because of their smooth surfaces the element of friction is largely missing in the mass, allowing the particles to slip freely on one another, and that consequently the material offers less resistance against mobility than in the case of sand, the grains of which are angular and have, therefore, a considerable element of surface friction.

Whatever the reason, ordinary clay is highly plastic and as it is mixed with sand it becomes less so, — that is, less responsive to movement under pressure. The pure clays are, generally speaking, practically impervious to water. Porosity increases with an added content of sand, *i.e.*, when sand is present in quantity, it takes up water and yields it again if subsequently drained. Clay, on the other hand, has a considerable content of moisture of its own, but principally in mechanical mixture held there by capillary attraction, so that it is not readily given off. In some of the tests made during the construction of the East Boston Tunnel, clays taken from the harbor — stiff clays which required the application of considerable effort in excavating — developed, after baking in an oven, a shrinkage of approximately 20 per cent in volume, due to the driving off of the moisture.

This fact raises a very interesting question with respect to some subsidences which have occurred in this general locality in times past. For example, in the city of Cambridge, a large district with an axis along Albany, Portland and Main streets to Kendall Square, and in the other direction from Harvard Bridge to Central Square, has shown substantial subsidence over a long period of years. Since the Metropolitan Sewer was constructed in Portland Street thirty years ago, it has settled some 39 inches, due to general subsidence of this area. It may be recalled that practically every time Massachusetts Avenue is repaved in that locality it usually needs to be filled up a foot or more. The records of the City Engineer's office indicate a gradual and progressive subsidence of the entire territory. The locality is underlaid with a deposit of filling of moderate depth, 12 to 15 feet, with some mud or peat deposit beneath it. Then comes a layer of sand and gravel extending down to clay, which lies perhaps 20 to 25 feet below the ground surface. From this point to a total depth from the surface of about 140 feet nothing but soft clay is encountered until slate rock is found at the latter level.

With the knowledge that the relative volume of any clay has a definite relation to the amount of moisture it contains and that the removal of that moisture in whole or in part will cause a shrinkage of the mass, the theory respecting this subsidence which has had the widest acceptance has been based upon the supposition that the removal of water from this soft clay, and the consequent shrinkage of the mass, has been responsible for the observed phenomona. The settlements which have occurred are not localized. They occur over the entire area, and whereas heavy masonry buildings supported upon piling may settle 15 or 18 inches in a period of years subsequent to their construction, no cracks appear because the whole structure sinks uniformly and simultaneously with the surrounding area. The movement is one of gradual shrinkage of the entire underlying soil.

Evidence of a similar subsidence of an earlier period was found in the vicinity of Copley Square during the construction of the Boylston Street Tunnel, where traces of former marshes were uncovered, with fish weirs set in them at depths of 12 to 15 feet below low tide. That marsh level must some time have existed well above low tide elevation and presumably at not a very ancient geological period. The subsidence was apparently similar to that referred to in the Cambridge section and the general soil conditions and arrangement are quite similar.

The argument is often advanced that if water is removed from sand a similar shrinkage will necessarily result. I have never been able to accept this theory as accurate for the reason that the sand grains themselves are to all intents and purposes small fragments of gravel or rock. The mere fact that they are minute in size does not alter their behavior. They are independent particles resting one on another. That they possess a considerable resistance to crushing is evidenced by the knowledge that they have withstood the test of transportation through the glacial period and the subsequent movement in water with its consequent abrasion. They consist of hard unyielding particles resting in as close proximity to each other as is physically possible, and such water as is present merely serves to fill their voids. The sand grains themselves ordinarily possess no power of absorption. They neither swell nor shrink under the influence of moisture. When the water in the voids is drawn off, therefore, the sand particles still rest upon one another as they formerly did in the wet condition. I have never observed any case in which the withdrawal of water from sand strata caused subsidence in the surrounding soil unless some of the sand itself was removed with it. In case such action did occur it would be very apparent in the vicinity of driven wells where the water level is frequently drawn down to a considerable depth in the overlying sand. I have never heard of an occurrence of that sort.

It is a matter of common knowledge that if a trench is loosely filled with sand and is subsequently flooded with water, it becomes consolidated and compacted. The presumption would be, therefore, that the mere submersion of sand in water would tend to consolidate it and the subsequent withdrawal of the water could not be expected to arrange the particles in any closer proximity to each other.

I want now to speak rather briefly with respect to the ability of vertical walls of various soils to stand unsupported. Of course any granular material which is perfectly loose and free to move will not stand for any appreciable height in a vertical plane, because it possesses no cohesion, that is, no tensile strength. Such a material must depend solely upon a weak mechanical bond due to the interlocking of particles which is very easily disturbed by vibration or shock. Granular materials, however, do not constitute the principal classes of soils encountered. Usually there is some material in combination with the granular particles, perhaps a clay or some other cementing medium. It may be a matter of some surprise to know that natural clays frequently develop tensile strengths of from 100 to

200 pounds per square inch, and the amount will grade downward with the addition of sand until in the case of purely granular material there is no tensile strength whatever. The admixture of clay, therefore, imparts tensile strength and cohesion, and in this condition soil will stand as an integral mass until the weight of the vertical bank becomes so great that it exceeds the natural tensile resistance of the particular material.

There is one peculiar characteristic with respect to the yielding or caving of the banks of excavated trenches. It does not seem to make any difference what the material is. Practically all cave-ins that occur in the sides of a trench, due to lack of adequate support, produce a break along the surface that is at a distance back from the edge of the trench substantially one-half the depth of the excavation. It is always possible to predict about where the break will occur, if the depth of trench is known. The line of fracture which occurs in the bank at right angles to the trench will not usually be a diagonal to the surface. It will approach more nearly a quarter circle in direction and will extend vertically downward from the ground level for a short distance and then curve in toward the bottom of the trench. Such, at least, has always been the result of my observation.

It is a somewhat common theory to consider the material of a more or less fluid or semi-fluid nature and to design the trench bracing with that idea in view. Under such assumptions much heavier pressures may be expected at the bottom than at the top. As a matter of fact, however, the practice of almost all experienced superintendents is to place the heavier timbering nearer the top. They realize from their experience that it is there the heaviest pressure is usually found. It is not at all unusual, in the case of a trench having clay banks in which cracking has already taken place and some slight initial movement has occurred, to find it possible to remove some of the sheeting at the bottom of the trench and actually to undercut the excavation at that point without causing any further movement, whereas if actual pressure existed at the bottom this would be a most dangerous procedure to adopt. The explanation is that in the ordinary case the mass of earth behind the sheeting moves as a sort of monolithic wedge with its center of pressure applied approximately one-third the distance down from the surface. Of course, some exceptions might be made to such a general statement. It might not hold true, for example, in a flowing sand which tended to run in through openings between the planks or where perhaps it boiled in under the bottom of the sheeting. Such a sand is not in a solid, but in a fluid condition. Even under these circumstances, however, the action may be largely local. The mere fact that water is present in a sandy material does not necessarily give it fluid properties; and if the local action of flowing can be eliminated, this type of soil may readily display the typical behavior of the more stable materials.

It may frequently be a moot question whether a trench requires bracing or not. A majority of trench accidents are the result of errors of judgment in assuming that because their banks stand up for short periods without lateral support, they will continue to do so indefinitely. Often they do stand for a time and then suddenly fall with little warning. I am always inclined to be apprehensive concerning the trench that appears to stand without support, because when it does let go it usually caves suddenly in a large mass and there is little chance for the workmen to escape. There is no such danger in the case of a loose granular material, because generally it gives some preliminary warning. Usually there is a rattling down of the loose materials, indicating in advance that a movement is taking place in the material. It is a safe rule to apply some restraint to any bank, particularly if the trench is carried to a considerable depth.

When banks stand, either entirely supported or with some slight restraint such as may be afforded by light stay braces at 6 or 8 feet intervals along their length, it is due to the cementing quality in the material. The pudding stones which we find in this locality are supposed geologically to have been formed by the consolidation of sand and gravel deposits through the agency of mineral solutions in the ground water, which have gradually cemented the particles together. Similarly we meet various other stages of the cementing process in our several soils ranging from ordinary clayey material up to the iron oxide combinations which we commonly observe in many forms of hardpan. The latter produces an extremely strong material of very high tensile strength. It will stand almost indefinitely for any ordinary depth.

In the case of clay trench banks there are other considerations that frequently enter into the problem. Our local blue clays will stand remarkably well when first excavated. A peculiar characteristic of our local clays is that after they are exposed to the atmosphere for a brief time they air slake. Such exposure seems to produce a chemical change in the material, thereby breaking down its cementing properties. It gradually loses its natural blue lustre, the exposed surface tends to disintegrate, and ultimately as the air penetrates and the moisture drys out the bank may fail suddenly and slide into the trench. This is a very common cause of trench accidents in this locality. On the other hand, most of the yellow clays do not display this characteristic. As a rule a trench in hard yellow clay will stand almost indefinitely unless subjected to alternate freezing and thawing. This difference is due evidently to the presence of iron oxide, the most dependable of the cementing agencies. At one time the clay must have existed above the sea level, and its buff color was derived from the action of the air on its iron content, resulting in binding the clay particles together and imparting to the soil strength and tenacity which apparently become permanent, resisting any further action of air and the elements. In any event, a yellow clay bank, as a rule, will stand up substantially without limit, barring weathering of the face.

Frequently we encounter sandy clays in which a large amount of fine sand is intimately mixed with the clay. In such instances the more sand it contains the more moisture it will hold. Ordinarily a soil that holds water will drain readily, become porous and lose some of its plasticity. Provided the sandy clay contains no water it will usually stand fairly well. The presence of fine sand seems to assist in maintaining stability; but whenever a sandy clay gives off water, it usually disintegrates somewhat because the sand is washed out of the clay and leaves voids which assist in a subsequent breakdown.

In many cases sand veins exist in the form of horizontal layers. These may vary from an inch to a few feet in thickness. Whenever such a streak, existing below water level and therefore containing ground water, is exposed, the water will drain out, usually carrying some sand with it, thereby undermining the mass above, causing it to break down from its own unsupported weight.

One of my earlier experiences as a foreman occurred in the town of Belmont in the year 1894. Along Concord Avenue we had occasion to excavate a sewer trench about 30 feet in depth, and encountered therein a very hard clayey material which held fairly well with corduroy sheeting; that is, instead of placing the vertical planks close together, a space was left between them so as to economize on lumber. Apparently the bank, if it were to move at all, would move as a body, so there was no particular reason for sheeting closely. Near the bottom of the trench a vein of fine water-bearing yellow sand about one foot thick was encountered. On one side of the trench the ground sloped upward steeply toward a much higher elevation. On the opposite side of the trench were some deep clay pits of the brick yards closely adjacent to the street. When the fine yellow sand was uncovered a foot or so above grade, just enough water and sand seeped out to remove the support of the clay bank above it, so that the bank cracked with the characteristic type of fracture and laid over very heavily against the bracing, with the result that the lower side of the trench yielded and moved bodily toward the clay pits. Before the pipe could be laid the trench was so much inclined that it was impossible to plumb down from the top. It was necessary to fleet over halfway down and plumb from that point in order to reach the bottom. That was an extreme case of this kind.

Another property which clay sometimes possesses is a tendency to flow, somewhat as will a viscous liquid. This action was clearly observed during the construction of the East Boston Tunnel under State Street in this city, where a tunnel shield was employed in conjunction with the pneumatic process. Pilot drifts were driven in advance in which were constructed the side walls that subsequently supported the roof shield.

These drifts were 8 feet square in cross section. They were lined solid with 8 by 8 inch timbers. Instead of driving lagging as is commonly done, the clay was cut out perfectly square with a level roof and vertical sides. Oftentimes as much as 8 to 10 feet of heading would be excavated at a time without any timbering whatever. The clay would stand beautifully without support, and subsequently it would be lined by simply erecting sets of legs and caps close together, making a solid wall and roof of the 8 by 8 inch timbers. We found, however, at the end of 48 hours there was usually a noticeable cutting in by the legs into the caps, and this often progressed until the cap was cut nearly in two under the pressure. It was found that the initial settlement on the street surface occurred about 75 feet in advance of the excavation. The clay seemed to flow toward the tunnel heading, the settlement growing more pronounced as the heading advanced. There was an ultimate maximum settlement of 10 to 12 inches over the roof of the shield by the time it had finally passed by. The tendency for clay to flow makes it a somewhat dangerous material in the case of deep trenches or tunnels because of the fact that it possesses, in addition to its natural weight as a vertical bank, an increased pressure from the latter action. For example, deep excavations in blue clay in a narrow street may endanger the buildings on either side from this cause; and although State Street is very wide below the Custom House, settlements of buildings were quite general. These settlements varied from ½ to 1½ inches.

Quicksand

Coming now to the question of quicksand, I may say that I have reached the conclusion, after many years of experience, that one probably ought not to speak of quicksand as a *material*. Rather we should look upon it as a condition of a material, because the same substance which displays all of the characteristics which we recognize as quicksand may under other circumstances be just as stable and as satisfactory as dry sand. The readiness with which it flows and the facility with which it boils and becomes unstable are not natural qualities. They are usually artificial in character and are produced as a result of the methods followed in the process of excavating. They develop as the natural consequence of an unbalanced head that causes water to flow upward through the sand; and whenever this action occurs a *quicksand condition* may be produced in almost any class of granular material, regardless of the size of its grains, depending only upon the volume and velocity of flow.

Allen Hazen, a well known consulting engineer of New York, in a discussion in which he participated before the American Society of Civil Engineers some years ago, submitted a definition of quicksand which has always seemed to me to be complete, inclusive and simple. It was substantially this:

> Quicksand is a sand containing for the time more water than would normally be required to fill its voids, and, therefore, with its grains held a slight distance apart so that they flow upon each other readily.

In other words, if the normal percentage of voids in a granular material is, say 40 per cent, and water under pressure is forced into these void spaces so as to separate the grains slightly, thus increasing the total voids to slightly more than 40 per cent, a quicksand condition will be established.

Imagine a container in the form of an inverted cone filled with a mixture of sand and water. Obviously the volume of water will be identical with the volume of voids in the sand. The presence of the water under such circumstances will have little influence upon the behavior of the sand. Usually it will be found to be stable under loading and will display most of the characteristics of a dry sand of similar composition. If, however, a water pipe is connected to the apex of the inverted conical container and water under pressure is permitted to flow upward through the sand grains so as to fill and overflow the container, the properties of the sand will be changed.

Under such circumstances, the grains will be forced slightly apart, due to the pressure of the water which is exerted against the frictional resistance to its passage through the sand voids; and when in this condition the individual particles will be free to move in any direction with comparatively little restraint. As a result, the mass of sand becomes unstable and any load applied to its surface will have no difficulty in sinking into it, easily pushing the several sand grains out of the way in consequence of their ready mobility.

It will, of course, be obvious that the particular degree to which such an action takes place will be affected by many considerations, as, for example, the size and shape of the individual grain and the relative velocity and volume of the flow; but the general principle governs in all cases, and the observed phenomena referred to is typical of all cases of quicksand behavior.

Fine sands sometimes display instability under loading because of the presence of a certain admixture of clay which acts as a lubricant to the sand grains and thus facilitates their mobility. This class of material should not be confused, however, with that produced as a result of upward water flow.

As an instance of the practical application of this theory to actual conditions encountered in excavations, let us consider the sequence of happenings in a specific case. The typical combination of underground conditions which induces quicksand behavior involves a substantial depth of fine sand underlaid by a stratum of coarse sand or gravel charged with ground water under a sufficient head to induce an upward pressure in the layer of fine sand above it. The latter, being a porous material, will under such circumstances become impregnated with the ground water up to the level which produces the head, in other words, to the ground water level. In this condition it resembles in all respects the original or static condition of the sand in the conical container previously described. The water merely fills the voids in the sand, and otherwise the nature or behavior of the latter material has in no important respect been altered.

If, however, a trench or pit is excavated in the fine sand to a depth below the ground water level, and the inflowing water is pumped from the excavation so as to maintain the bottom of the excavation in a dry state, it must be apparent that there will be an unbalanced head created such as will induce an upward flow of water from the coarse stratum below through the intervening layer of fine sand and into the bottom of the trench or pit. There will then exist the same condition referred to in the case of the imaginary container where water was permitted to enter from the bottom and flow out at the top. In other words, the fine sand under these circumstances becomes a quicksand. It should be noted, however, that the quickness is produced artificially by the excavation and pumping, and does not appear in the normal state of the material so long as there is no unbalanced head of water.

A situation such as that just described frequently presents very serious difficulties from the construction standpoint. If the depth of excavation below the normal ground water level is considerable, the flow soon becomes so violent as to bring up quantities of sand mixed with the inflowing water, thereby raising the bottom level of the trench, in which case it may be possible to excavate continuously for an entire day without appreciably increasing the depth. Frequently such a trench may be left at a given depth at the end of the day and will be found to have a much less depth by the following morning when work is resumed, due to the inflow of sand from the bottom during the night while work is suspended. The sand which is thus washed up with the water is immediately replaced by other material that flows in laterally from the surrounding soil, thereby causing a disturbance of the ground on either side of the excavated opening, sometimes extending for considerable distance in all directions.

In such a case, when the difficulty becomes pronounced, it will usually be found more effective and economical to eliminate the troublesome action by driving a series of "well points" through the bed of fine sand and into the coarse water bearing stratum and to pump the water therefrom so as to pull down the surrounding ground water level to an elevation somewhat lower than that of the excavation. In this manner the work may proceed in the dry and the pumping is done entirely from the lower level rather than from the open trench.

Many instances of so-called quicksand action, however, may be due to a different cause. In some cases the coarse water bearing stratum is entirely missing and the fine sand is merely saturated with the ordinary accumulation of surface water which completely fills its voids. If an excavation is made into this material, using reasonably tight sheeting, the water will be dammed up behind the latter to a level higher than that of the trench bottom, and will consequently exert a pressure tending to produce a flow downward and under the points of the sheeting and thus to escape into the excavated opening. In case the pressure is sufficient to permit of such a flow, sand will be carried with it from behind the planking of the trench, thereby producing the same difficulties previously enumerated in the case of inflow from the lower level.

The remedy for this difficulty will usually be found in the use of longer sheeting driven to a greater depth, so as to increase the length of travel of the water and sand before entering the trench and thereby diminishing its ability to do so. Also, whenever confronted with this particular kind of problem, the engineer will usually find it greatly to his advantage to use matched or tongued and grooved sheeting. The slight additional cost will easily justify itself in view of the superior effectiveness of this material over ordinary square edged sheeting.

The method just described will ordinarily be found equally effective in preventing the "lifting" or "swelling up" of fine sand trench bottoms due to their somewhat semi-fluid nature during the period of unbalanced water head. In such cases the weight of the banks on either side of the excavation tends to push the bottom of the trench upward much as might be expected in the case of very heavy viscous fluids.

A method of handling this particular type of excavation was devised some years ago by the city of Boston Sewer Department, and it is possible that Mr. Edgar S. Dorr may have originated it. A series of 12 inch pipes were driven to a considerable depth below the trench bottom and subsequently washed out. As I recall the arrangement, a 2½ inch perforated pipe or "well point" was then inserted inside the first pipe and the annular space between the two was filled with coarse Plum Island sand, after which the 12 inch pipe was withdrawn, leaving the smaller pipe surrounded with coarse sand which served to collect and deliver to the well points the water which drained out of the fine sand. Ejectors were used to remove the water which accumulated in the 2½ inch pipes.

It is my recollection that this method did not prove sufficiently effective to warrant the expense of installation, but probably Mr. Dorr will be willing to enlighten us upon that point.

I have had frequent occasion to use this principle in the securing of relatively small supplies of water from ground sources when ordinary driven wells could not be used. Steel cylinders 3 feet or more in diameter were driven down and excavated as open wells. When a sufficient depth had been reached a perforated pipe was inserted vertically in the center and the surrounding space filled with graded gravel and sand, after which the cylinders were withdrawn and the ground water permitted to filter in through the coarse material, from which it could readily be pumped through the perforated pipes. In this manner several fairly satisfactory water supplies of small capacity have been obtained from soil that otherwise would not be available for the purpose.

Of course there may be extreme cases in which none of the methods previously outlined would prove satisfactory for handling an excavation in quicksand. In that event resort must be had to the pneumatic process, which generally may be relied upon to accomplish the necessary results when all other means fail. This is often so expensive as to render it nearly prohibitive in a large proportion of cases.

There exists a considerable popular misconception concerning the qualities of fine sand, especially respecting its ability to support a load. My judgment is that if it is a true sand, its behavior under loading will not differ materially whether it is wet or dry, regardless of how fine it may be.

During the early stages of the war I was called upon to advise a contractor who was constructing a large war plant under a rush order. In excavating the foundations very unstable quicksand was encountered. To secure and drive piles for the foundations would require thirty days or more, and the contract time was not materially greater than that for the completion of the entire work. The question involved was as to a possible alternative method that would furnish satisfactory foundations for the building. I asked the contractor if he had considered building it upon the sand itself. He did not take me seriously at first. He called my attention to the fact that a man would sink up to the hips in this sand and have to be pulled out with a rope. I took him over to one of the pits in which the water had been allowed to resume its normal level. We shoved a 2 by 4 inch scantling down through the water and found the sand so hard that no impression could be made upon the bottom. It was thoroughly compact and unyielding. We finally decided to make an actual test upon it. The floor of one of these pits was covered with a layer of concrete one foot in thickness, and in the center of this layer was inserted a frustrum shaped metal form, which was heavily greased on the inside surface in order to prevent adhesion of the concrete which was to fill it. The base of the metal form was 24 inches square, so that the block of concrete that filled it had an area of 4 square feet of bearing upon the sand. This block was loaded with a test load which ultimately ran up to something like four tons per square foot and showed a total settlement of less than one-quarter of an inch. We finally decided upon a loading of two tons per square foot, and all footings were built directly upon the sand. After a lapse of six years or more that building is still standing without any visible evidence of settlement.

I mention this experience as indicative of the fact that the material which we call "quicksand" is not quick in its normal condition.

The fact should not be overlooked, however, that there are dangers incident to building upon such a material because of the possibility of subsequent undermining. Some later operations in the vicinity may cause a movement of the adjacent ground, and if carried to a lower elevation may affect the stability of the former structure.

There probably exists a greater amount of popular misconception regarding quicksand and its properties than almost any other phase of engineering knowledge. The subject has been commonly regarded as surrounded with an atmosphere of mystery and conjecture to which it is not properly entitled. This mysterious element has been frequently elaborated upon in both fiction and fact, with the result that to-day much groundless apprehension persists regarding its dangers and difficulties. It would be extremely helpful if engineers generally, having to do with excavation and foundation work, would address themselves more earnestly to a clearer understanding of the phenomena to which we have given the name "quicksand."

Discussion

EDGAR S. DORR:* Colonel Gow referred to one of the jobs we had in the Sewer Department. I remember that very well indeed. It was on St. Joseph Street in Jamaica Plain. I hasten to disclaim, however, being the author of the scheme, because I wasn't. It was Guy Emerson's. The scheme was a little different from that shown by Colonel Gow, although the principle was the same. The pipe wasn't as large as that — 6 or 8 inches in diameter, I should think, and not perforated. It was driven down and a smaller pipe inside of it. Then it was washed out and when it got down 6 or 8 feet below the grade to which it was going, a large cavity was blown out by the water pressure at the bottom of the pipe, — a hole that might hold a barrel; and while the water was still going coarse gravel was dumped down into the annular space between the pipes, and filled this cavity, and the drainage was effected through this gravel. An ejector was sent down the interior pipe and the water pumped through that. It worked very well indeed. Pipes were put each side of the trench and kept driven a considerable distance ahead of the trench, and it lowered the ground water in the quicksand enough to dry the trench out so that the digging was done practically in dry sand.

If I ever knew the cost of it I don't remember it now, because the work was done about 1900, but drainage was effected in that way and not through a perforated pipe. I think the process is perhaps a little cheaper and quite as effective.

I would like to describe a method of handling quicksand devised by Howard A. Carson, by putting down a form 6 inches inside the sheeting of the trench, and feeding gravel down between this and the sheeting as the sand is dug out from between these false forms. The gravel drops down and comes through.

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* Planning Engineer, Public Works Department, 707 City Hall Annex, Boston, Mass.

In a short time it closes up across the bottom and you have a beautiful gravel bottom which the weight of the sand and gravel holds down. The water comes through it and is drained off. That has been very successful.

QUESTION: I would like to ask a question about the design. If the direct pressure does not increase as you go deeper in the ordinary stiff soil, what pressure would you design for, if a permanent structure is to be built and in the case of a soft clay, as you go down, does the pressure increase?

COLONEL GOW: I see no reason why the same assumptions should not be applied in determining the pressure against a retaining wall as in the case of the wall of a sheeted trench. I have had occasion to observe movements in the case of some retaining walls which figured amply safe according to the usual theory that could be readily accounted for by the solid wedge theory. Most of us who have had experience have learned that a wall is made safer against overturning if the fill behind it is deposited so as to slope away from the wall rather than toward it.

It may be that after the fill behind such a wall has been in place for a sufficient length of time, it will assume cohesion enough to be practically self-sustaining, so that theoretically it really produces less pressure against the wall than it originally did.

With regard to the pressure against such a wall from flowing clay, I presume that the theory of fluid pressure might apply, and yet even in this case once the flow is arrested the mass will be bound to act as a solid. As explained in reference to the East Boston Tunnel work, there was no evidence of pressure or movement when the clay was first exposed. The mass appeared to be set in motion as a result of the excavation, and this action did not manifest itself for some hours after the initial undermining of the soil.

LEONARD METCALF:* In amplification of this admirable talk of Colonel Gow it may be of interest to allude to a method of sinking wells for small supplies which has sometimes been used. A curb is built at the surface of the ground and the material is excavated from its center, permitting the cylinder of masonry to sink into place, leaving the water in place with no differential in head between the inside and outside of the masonry curb. Then the bottom is placed and loaded with graded sand and gravel. In that way the structure may be placed in material that couldn't otherwise be handled except by compressed air.

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In sinking wells at Concord, Massachusetts, twenty years or more ago, we used 10 or 12 inch pipe. The soil was sandy — almost like infusorial earth — with very little water, yet enough to influence the excavation. The contractor began by driving a double line of long sheeting without the recommended use of wells. The outer timbers were something like 36 feet long and the inner 22 or 24 feet. When he had got them down and began to dig he found after several days that the bottom of the excavation was higher than when he started. I had suggested driving a series of wells surrounding the structure. He didn't want to do this, and threw over the contract. Then Mr. Taylor of Worcester took up the work. He drove wells with 10 inch pipe, lowered a small pipe perhaps two inches in diameter into each well, put coarse sand between the inner and outer pipes, and then withdrew the outer casing pipe. There was so little water that he was able to use a pitcher pump upon each of these wells. I believe he kept one man going around, pumping the ground water and catching it in a pail or pouring it out on the ground. In this way he drained out the water sufficiently from the soil to make it firm and stable and was able to get the structure into place.

We had another example of the stabilizing action of which Colonel Gow has spoken, in a dam just completed at Plattsburgh, New York. The water behind the dam was to be about 45 feet in depth. As the water level rose in the reservoir during construction from 15 to 20 feet on the upstream side of the dam, the flow of water from one of the side slopes of the valley became greater and greater. A man walking along the foot of the slope 100 or 200 feet from the dam would sink into the ground in places halfway up his leg, showing that the water in the hillside was finding vent. Of course the danger there was that with the increased head of full reservoir we should later have land slides, which might finally destroy the structure. So we dug a sewer trench across the spillway, and when we had gotten down 6 feet or so, we found boiling quicksand, difficult to handle. We were several weeks putting into the trench a relatively short line of drain pipe. But it was done and by the ordinary methods Mr. Gow has described so well. Vitrified sewer pipe was put in the middle, and material grading from gravel to coarse sand outside of it. With the release of the water in it, the quicksand immediately became stabilized. Then we built such a drain along the hillside. Therefore we now have along the hillside a graded material, a filter bed on-edge, which will serve to relieve the pressure of water. As long as the graded sand and gravel remains in place any seeping water should pass off through it without undermining the structure.

In the case cited it was impossible to cut off the flow of water, which came partly from the hillside and partly around the ends of the dam. I think that this method of venting the water is safe and will maintain the stability of the dam and hillside.

Colonel Gow: Mr. Metcalf's remarks with reference to the sinking of wells have called to my mind another point. We sometimes have occasion to sink such wells in pits in which the conditions do not permit of unwatering the hole. In such cases we frequently use an orange peel bucket to remove the soil. Oftentimes in the case of very fine sand the bucket will not take hold of it because it is too compact. We usually find that we can remedy such a situation by inserting a jet pipe into the sand and agitating it. In a recent job we found we could even use compressed air for this purpose and that it operated just as effectively as water. In its normal state fine sand is very compact, and it is necessary to loosen it before it can be excavated.

When the Adams Square subway station was built in 1896 or 1897, we encountered great difficulty with ground water. The material excavated was a loose sand which contained enough water to require constant pumping. When later the Washington Street Tunnel was built in 1908 or so, it was constructed immediately under the old Adams Square station, and that layer of sand was found to be completely dried out. Some process had been going on which had drained out the former ground water.

When the sewer in Mason Street was built many years ago the material was very wet and unstable. When, however, Keith's passageway was constructed some years later, this ground was found to be absolutely dry. Whether the water is removed in the sewers, — which seems unlikely, for at least the two cases which I mentioned which lie considerably below ordinary sewer level, — or whether, as now seems more probable, it is due to the prevalence of artesian wells, of which there are a great many around the city, I cannot say. In constructing the foundations for the Custom House there occurred a very interesting experience. At a distance of 50 feet below the surface a layer of coarse gravel was uncovered which was perfectly dry, and whatever water entered the excavation from above ran down the sides and disappeared into the lower gravel stratum. This would seem to bear out the hypothesis that the large number of artesian wells about the city may be responsible for draining the water out of the surrounding territory.

MR. DORR: On one other point made by Colonel Gow, — in regard to the bearing power of quicksand, I quite agree with him. On the Stony Brook conduit a large concrete structure 20 feet by 17 feet was built some 500 feet north of Green Street, Jamaica Plain, nearly to Morton Street, and all of that material was not quicksand, but it would have been if it hadn't been unwatered. It was almost quicksand. It was quaking sand. We put no piles under that structure, and there has been no settlement. I don't see that it is in any danger, unless another structure should be built nearby at a lower depth. There seemed no probability, so we took a chance.

FRANK A. MARSTON:* Referring to the question of a previous speaker as to whether earth pressure may occur at the lower part of a retaining wall or nearer the top, it may be of interest to refer to a paper by J. C. Meem, *Trans. A. S. C. E., Vol. LX, June 1908, page 1.* The paper discusses in some detail the pressure of earth against trench bracing, together with examples from the New York subway work.

Referring to the sinking of wells and the forming of sand and gravel strainers, there is a method used by a middle western company by which a 24 inch shell is put down and within it a smaller shell, perhaps 12 inches in diameter, and between the two graded sand and gravel is placed in concentric layers varying from fine material at the outer periphery to coarse next to the well pipe. By this means it is expected that the structure will last a longer period of time than if the shell is simply filled with sand.

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I would like to ask Colonel Gow how he would account for so much trouble with settlement in Boston in the vicinity of South and Lincoln Streets. In that section there is a layer of stiff blue clay to a depth of about El.—20, underlaid with a stratum of sand and gravel. Is it possible that the construction of sewer and water pipe trenches has caused a gradual lowering of the ground water through the sand and gravel and a subsequent shrinkage of the clay?

Colonel Gow: I do not know of any general subsidence of streets in the district you speak of. Generally speaking that is not a bad territory from the subsoil standpoint. It is underlaid by a very good clay, — fairly dry stiff clay, — and at not very great depth. I think the clay on South Street, Lincoln Street and Kneeland Street is from 20 to 30 feet below the surface. It is overlaid with mud and with fill on top of that. I do not know of any conditions there comparable to that which you refer. If you have reference to settlement of buildings I am familiar with that. We have had occasion to make one or two examinations of buildings in that locality which have shown that the piles have badly decayed in many instances.

There have been a number of cases of settlement in that region due to decaying piles. There is a very low level of ground water there. We have found it as low as plus 3 or $3\frac{1}{2}$, whereas the piles are cut off at grade 6 or 7, and of course in that case the tops of the piles decay very quickly. That is characteristic to-day of many sections of the city, particularly through the Back Bay section. The wall around the Charles Street Jail on Fruit Street was examined by me four or five years ago, and there the ground water level was found at plus 2, although the water in the basin stands at grade 8. After the completion of the Charles River Dam we were called upon to drive test wells along the shore side of the marginal conduit, and I believe they were under observation for a great many years. We found the water level in most cases considerably below the assumed ground water level. Water from the basin was no longer permeating this area because the old sewer outlets had been cut off by the marginal conduit and the land was cut off completely from access by the water. The result was that the ground water level had lowered. There appeared to be no fixed relation, however. Some spots showed a low water level and in other places it was relatively higher. This might indicate that some source of artificial drainage existed near the lower spots.

GORDON M. FAIR:* I believe that in connection with Colonel Gow's talk on quicksand it might be of interest to mention a further cause of quicksand motion, especially with reference to hydraulic fill dams where a direct pressure is exerted upon the fluid core material by the toes of the dam. As long as the core material remains undrained, that is, as long as it remains saturated with water, it will act like a quicksand on being exposed to pressure. It will do so in accordance with Mr. Hazen's definition, because after being compacted by pressure there will be more water in the material than the voids can normally hold. If you take a material, for instance, with 50 to 70 per cent of voids and decrease the volume by 5 or 8 per cent by compacting the material, the same will tend to flow. I do not know that this theory has been actually substantiated, but it is a common belief that pressure will cause a quicksand condition on material that is saturated with water and can be compacted by pressure.

COL. FRANK M. GUNBY:† I don't believe in talking about anything underground when Colonel Gow is on hand. He has the faculty of making it all so simple and plain and easy to see. This discussion, like many of those that we engineers have, is about the troublesome kind of soil. I think you have picked out the worst side of construction underground when you talk about water.

I remember an interesting instance a contractor in New York told me about the subway construction in that city. Part of the excavation was open work and a lot of very fine sand was encountered. The sand, as I recall it, was very, very fine and there wasn't a great deal of water. But they were having a fearful time because they couldn't pump the water without pumping sand and if they pumped the sand, the whole neighborhood would be endangered. The problem was solved by digging a little hole and putting the pump into it. The hole was then enlarged and deepened, with slopes flatter than the sand would run on, and the work carried on slow enough so that the water would just ooze out of the sand and trickle down the slope. They just worked the bank back so it would stand where it was. They had sheeting on either side to keep the trench from getting too wide. Finally they had the bank sloped 200 or 300 feet up and down each side. They kept a flat slope so the water would just ooze out of the sand without washing the sand out with it. I understand that the sand was removed in layers only a few inches thick, so as to remove only the sand which had given up its excess water.

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MR. METCALF: It may be of interest to tell of an example with respect to the effect of water upon sand, observed in Porto Rico. At a number of points the coastal plain is low and the streams make through this low plain to the sea. The wave action is sufficient — 18 inches or so high — to beat up a barrier of sand closing the mouth of these streams, and for a number of hours the water is retained behind it and the beach is perfectly hard so that one may drive safely over it. Just before the difference in water level on both sides is sufficient to cause the impounded water to break through to the sea, however, the sand gets into a state of semi-suspension, and at that time those openings are exceedingly dangerous.

My friend, Mr. Verges, told me that, a short time before one of my visits, a family driving along the beach passed one of these lagoons formed by the action of the waves in beating up a barrier to the river just at the right moment; and although the sand appeared to be perfectly harmless, it really was in a state of semi-suspension, just ready to break through, so that horses and wagon and all went through the quicksand, and were engulfed. Not one was saved.

EDWARD S. LARNED:* It seems to me that the subject has been covered very thoroughly. I have been interested in the control of sewer bottoms where the flow of material in the bottom of the trench is occasioned by unbalanced pressure, and in many cases this resolves itself into a question of adding weight, immediately following excavation, of a sufficient quantity of graded material like screened gravel, broken stone, or even cinders, sufficient to withstand the unbalanced head, and when skillfully and expeditiously done this has been known to overcome what seemed like very serious difficulty.

This method has often proved satisfactory when ordinary methods, such as driving close sheeting to a greater depth, and ordinary attempts to drain by frequent pump wells, do not accomplish the result.

I believe there is a marked distinction in so-called quicksand, the degree of fineness is a most important factor, and, again, some sands contain an appreciable quantity of mica and clay in a very fine state of division, and such sand is much quicker than a coarser sand free from mica and clay, even though the latter contains as much or more water. There is material found now and then throughout New England that in the vernacular is called "lumlolli" or "gumbo" or "bull-liver." This, when first exposed, is a very firm material and will withstand a considerable quiet load; but the slightest agitation, as for instance the movement of the men's feet working on this bottom, will cause it to become "quick," and in that condition it is impossible for men to work in it. Instances have been known where by the use of a suspended platform (not touching the bottom) men have been enabled to excavate without disturbing the bottom; and then by adding weight in the form of graded coarse material, a later upward movement of the material has been prevented. This sort of material, by the way, is most difficult to drain by any ordinary system of bleeding or pumping.

ARTHUR L. GAMMAGE:† In quicksand is not the velocity of flow of water in direct relationship to the size of the particles?

COLONEL GOW: I should think there would be some such relationship. If there is sufficient volume and velocity of water you could make quicksand out of very granular material, and with a finer material less pressure and velocity would be required to create the same condition.

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MR. LARNED: There has been no mention of the process of freezing quicksand to prevent movement and make possible excavation and construction of the desired utility. I remember on one of the Croton aqueducts, New York, we ran into a considerable stretch of fine sand heavily charged with water, and it could not be held by ordinary methods of excavation and timbering; so the ground was frozen by driving pipes, containing the salt solution, around the perimeter of the structure, and in that condition it could be safely excavated and caught up with timbering by the use of close sheeting. It is possible that to-day this problem would be better solved by the pneumatic process.

JOHN E. L. MONAGHAN:* I think there is nothing I can add except that I was interested in the settlement through South and Lincoln Streets, and I can say that Colonel Gow has answered that question. I know quite well, because the city has had several suits on account of settlement of buildings in that vicinity. It has been claimed that the construction of the subways was responsible. There have been no cases where streets have settled, but buildings have done so, and in every case investigated it was found that the pile timbers had rotted because of lowering of ground water. It has dropped to as low as Elev. 3.5 in places and pile tops have averaged Elev. 5.5.

HARRISON P. EDDY, JR.:† The effects of lowering the ground water table in a developed city are interesting, and are most surprising until one realizes the extent to which the water level may be depressed even in the most thickly settled districts of cities where, of course, there are no visible signs of any wells.

We had occasion recently to investigate the amount of water drawn from the ground by the factories in an intensely developed industrial city, in the course of a study of its sewage disposal problem. The mills used large quantities of water for process purposes, boiler feed, flushing toilets, washing, cooling, running elevators, etc. We found in this case that the mills obtained three times as much water from wells and streams (mostly from wells) as they did from the municipal water system.

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MR. DORR: I'd like to ask Colonel Gow if he thinks the artesian well theory explains the settlement in Cambridge?

COLONEL GOW: I shouldn't suppose that clay would drain readily enough for that, although it is possible. My thought has always been that with the increase in heavy street traffic and the presence of the Grand Junction Railroad through that section, together with the heavy street car traffic we now have, — all things combined, have induced vibrations which have brought the water up and out of the clay. It is the same principle which applied to the mud pies we used to make as children, — quaking it to bring the water to the surface. I should suppose in some vague way that such an action might occur. If artesian wells were responsible and water were being drawn down through the clay one would expect the gravel immediately overlying the clay to be drained out. But there seems to be just as much water as ever in that stratum. Of course there are very many theories, but this one seems to me to be the most plausible. The thought is very strong in my mind that the subsidence is caused by a shrinkage in that layer of clay, something over 100 feet in thickness. It is very soft clay.

MR. DORR: Isn't there also a theory that it might be caused by the dredging of great quantities of gravel from Charles River and movement in that direction?

COLONEL GOW: I have heard that theory expressed also, but I think it unlikely because the maximum settlement in that event would be expected to occur adjacent to the river, whereas in reality it is some 1,000 feet back from that point. The bench mark on the Cambridge abutment of Harvard Bridge has sunk one inch in thirty or forty years. There is greater settlement in Portland Street, Cambridge, which indicates that it cannot be due to that cause.

ACTIVITIES OF THE FEDERATED AMERICAN ENGINEERING SOCIETIES

Engineers Attend Public Works Conference

Engineers from all parts of the country assembled on January 9 to participate in the Public Works Conference called by the American Engineering Council. This Conference was considered by many to be the most successful yet held on the subject. It showed what the engineers could do when they united their efforts in a great public endeavor.

The well known mining engineer from St. Louis, Mr. Philip N. Moore, who has been associated with this movement since its inception, opened the meeting with a concise summary of the work that has been accomplished, reviewed the status of the plan for Government reorganization as it stands before the Cabinet and Congress, concluding his remarks with the following statement:

> The present plan of reorganization does not completely carry out our original desires, but it includes a reorganization of the Department of the Interior which shall carry two subdivisions, one a Department of Public Domain to have charge of the Government property, lands, parks, and everything of that nature, and the other a Department of Public Works to which it is requested that an engineer shall be appointed head, under the title of an Assistant Secretary.
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> This Department of Public Works carries not in every intimate detail the items of our original wish, but it is so substantially in line with it that it has occurred to many of the engineers meeting in Council that it were wise to accept it practically unchanged and to get behind it as a measure which can be approved by the engineers and the architects and the constructional bodies of this country as a practical, workable remedy for some of the mistakes and inefficiencies which we all know to have existed.
>
> It was to acquaint the profession with this situation, to take council with their representatives, and to seek their advice that this meeting has been called.

Outstanding among several important addresses were the remarks of Secretary Hoover. After assuring the delegates of his full sympathy in their effort for the establishment of a Division of Public Works, he reiterated his belief that the obvious economies to be had by consolidation of construction activity were "purely incidental to what the engineer is endeavoring to accomplish." He then went on to say:

> What we are wanting to accomplish and what is of far more importance than that is that we should have some central point for the inauguration of national policies of construction, some point where there can be a consideration given to the whole construction policies of the Government and their correlation to the private construction agencies of the country. Indeed, the Government is vastly involved in problems of navigation, waterways, and port improvement, and it is vastly involved in problems of reclamation. During the last three years there have been many problems of power, on a very large scale, that have formed a large part of this work. At the present moment works of that kind are being dealt with in anything from five to fifteen departments or agencies of the Government. At this moment in the consideration of certain problems of water power in the northeastern section of the United States, in an endeavor to find all the activity of the Government, I have set up a small informal Board embracing the heads of six departments of the Federal Government.
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> It is important that we should have efficient national operations or policies that look far into the future, as we must look, for the American people with all their ingenuity and activity, with all their demands and desires, insist on doubling the quantity of goods they want somebody to move every fifteen years, and we cannot continue as a safe and sound economic system if we are going to trust to the outlook of the next twelve months to provide for the transportation we require in the next generation. We have done that for the last thirty years. One consequence of it has been that we have had periods of time when transportation agencies have been practically at a standstill and it is no stretch of the imagination to conclude that the cost of the stagnation of transportation in 1920 alone would exceed a billion dollars.
>
> There are problems that naturally come to the engineer. It must be his foresight and his vision that will find a solution, but there must be some central point in the Government where these problems may be solved and where policies looking to their solution may be inaugurated. At the present moment we are dependent on the knowledge and vision of four hundred and eighty different members of Congress, representing different sections of the country. In the adoption of legislation bearing on the improvement of harbors and navigable streams, and so forth, the net result has been that we have improved vast numbers of streams that have no great demand for traffic. There has been no study of the transportation needs of the country as a whole, no marking out of priorities in relation to needs, and we have wasted a vast sum of public money, enough to have paid the whole administration charge of a department for perhaps two generations. . . .
>
> We should make use of the construction industry to stabilize the whole economic fabric, but there is no possibility of bringing Federal interest and

municipal help into constructive action unless there is some leadership in some Department that can give time, give study, and speak with authority on these questions.

So then this question is one of far more import than the detail that may appear on the study of any Government plan of reorganization.

Mr. Hoover then reviewed the efforts to find a practical plan from the point of view of actual work and the political setting which had to be met. He pointed to the impossibility of establishing a Cabinet position at the present time for the many activities that were seeking such position. Therefore he counseled the advisability of starting with a Division of Public Works and building upon that foundation. He drew the engineers' attention to the fact that there were many other engineering functions of the Government which would not properly come under the Division of Public Work, but which should be placed under an under secretary who is a man of engineering training and character. As examples of such bureaus he cited the Bureau of Standards, the Patent Office, the Bureau of Mines, etc.

In concluding, he urged that the Government departments be reorganized on the basis of their major purposes. Further, he warned against the kind of an organization that depended upon a particular man with a particular caliber because Cabinet officers of necessity have to be political appointees. The use of under secretaries, however, would, with the offices and bureaus which they represented, be a central point for a national thought and national construction in the line in which they were engaged.

Mr. Willoughby, Director for the nstitute of Government Research, who has spent a great deal of time in studying governmental functions, addressed the Conference in a clear and concise manner from the standpoint of technique. He warned that any plans suggested by the engineers would have to be dealt with by a thoroughly non-engineering body and that in view of this fact the engineers would do well to anticipate the misunderstandings that are bound to arise. Mr. Willoughby referred to the present haphazard construction of the Government departments by likening it to a farm establishment in the olden days when the farmer would build a shed and add length after length to his original shed until he finally had a structure that was put together without any idea of harmony at all.

Mr. Willoughby reviewed in some detail the great problem that the Government had in financing the inefficient machinery which it had set up to do its business, and he referred to the further inefficiency of the personnel system, which was rapidly driving those people who had chosen it as a career away from Government employment. This applied, he said, to over five hundred thousand employees.

Mr. Graves of the United States Bureau of Efficiency also addressed the Conference, reviewing in some detail the work that his organization had done with the investigation of the efficiency of the Government and referring to numerous of his personal experiences which pointed to the necessity of reorganization.

The keynote of the Conference was struck when the following resolution was unanimously adopted:

Whereas, The present structure of the Federal departments represents the unpruned growth of many years and is imperfectly adapted to present needs; and

Whereas, Definite recommendations have been made by both President Harding and President Coolidge emphasizing the need of a reorganization of public business, and a plan of general reorganization of departments is under consideration by a joint committee of Congress; and

Whereas The engineers and architects, and related technical professions of the country, have for many years advocated the establishment of a National Department of Public Works in which the matters relating to public works might be administered and co-ordinated; and

Whereas, The consideration of recent bills for the creation of a Department of Public Works was suspended in the interest of a general reorganization; and

Whereas, This subject has received the careful consideration of this Conference, representing more than sixty engineering, architectural and related organizations from all sections of the country; and

Whereas, The establishment of a Department of Public Works would make it possible to place governmental engineering and architecture on planes reflecting the highest achievements in these professions, known to the world; and

Whereas, A co-ordinated functioning of all public works agencies would be able to stabilize business and employment by expanding public work when private industry and employment may be slack, and by reducing such work as far as practicable when private industry may be fully absorbing the available supply of men and materials; and

Whereas, The advance and co-ordinated planning of public work is sound economy in that it permits the government to execute less work at peak prices and more work at the lower prices prevailing during dull times; be it therefore,

Resolved, That this Conference of engineers and architects, and allied interests, heartily approves the movement for a reorganization of Federal departments, and it particularly indorses grouping and co-ordinating within an existing department, preferably renamed a Department of Public Works, the construction and administration of all non-military public works.

Immediately after his opening address Mr. Moore was selected from the floor to be chairman of the Conference, and he later appointed a strong legislative committee, composed of the following men:

Col. J. H. Finney, Chairman.
Mr. D. Knickerbacker Boyd.
Mr. J. W. Cowper.
Col. C. R. Gow.
Mr. Fred R. Low.

Provision was also made whereby the American Engineering Council was put in charge of the promotion of the purposes for which the Conference was called; and an advisory council, composed of one member from each organization interested in the purposes of the Conference, are to be invited to co-operate. Plans are already in progress for the appointment of such representatives by the Presidents of the respective organizations that have assisted in this work.

Eighty-nine engineers officially attended the Conference, representing sixty-six engineering and allied technical organizations whose total membership is estimated to be in excess of 150,000 engineers, architects and constructors. The Boston Society of Civil Engineers was represented at this Conference by the President, Frank M. Gunby, and by Colonel Chas. R. Gow, who has been the representative of the Society on the American Engineering Council during the past two years.

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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS

BOSTON SOCIETY OF CIVIL ENGINEERS

BOSTON, January 23, 1924. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.45 P.M. by the President, Frank M. Gunby. There were about 130 members and guests present.

The minutes of the previous meeting were approved as printed in the January JOURNAL.

The Secretary announced the names of those elected to membership by the Board of Government at a meeting held today.

Members : Irving Ballard Crosby, Walter R. L. Josten, Zoltan Klein, Edward J. Simpson.

Juniors : Carl Bartlett Emery, George Harris Meserve, Jr., Leo Thomas O'Leary, Norman Prescott Randlett, David Shapiro, Roger Winthrop Squier, Benjamin Eugene Sullivan, Clarence Rodolph Wickerson, Henry Israel Wyner.

The Secretary announced the death of two members of the Society, Charles A. May and Walter H. Sawyer, both of whom died on December 21, 1923. The President stated that committees would be appointed to prepare memoirs.

After a brief statement by the President concerning the Society's membership in the Federated American Engineering Societies, the Secretary presented the following report for the Board of Government:

JANUARY 23, 1924.

To the Boston Society of Civil Engineers:

The Boston Society of Civil Engineers became a member of the Federated American Engineering Societies in April, 1921, by vote of its members. It was hoped that developments would be sufficiently serviceable to demonstrate to us the value of devoting a part of our funds to this National movement.

A study of all the conditions surrounding the Society's membership in the Federated American Engineering Societies has convinced your Board of Government that the expenditure of such a considerable portion of the Society's income for this purpose is not warranted, in view of the needs for local activities which are hampered thereby.

Your Board of Government therefore recommends that the Boston Society of Civil Engineers withdraw from membership in the Federated American Engineering Societies on or before June 30, 1924, under the means provided, and that the question of withdrawing be submitted to the membership by letter ballot.

For the Board of Government,

FRANK M. GUNBY, *President.*

Frank A. Marston then presented the following motion, which was duly seconded:

That the recommendation of the Board of Government that the Boston Society of Civil Engineers withdraw from membership in the Federated American Engineering Societies be accepted, and that the question — "Shall the Boston Society of Civil Engineers withdraw from membership in the Federated American Engineering Societies" — be submitted to the membership by letter ballot.

After expressing the view that this matter should not be acted upon hastily, Mr. John E. L. Monaghan moved and it was duly seconded:

That this motion be laid upon the table and that a date be set for a special meeting for the discussion of this subject.

Upon a vote being taken, the President declared the motion of Mr. Monaghan carried, and stated that a special meeting would be called in the near future for a discussion of this subject.

Upon the completion of business, the President announced that this was a joint meeting with the Designers Section, and that they had made all the arrangements and were now going to run the meeting, whereupon he introduced Walter W. Clifford, Chairman of the Designers Section, who presided during the remainder of the evening.

The subject was "Fire Protection in Building Design," and the first speaker was E. A. Barrier, Vice-President, Arkwright Mutual Fire Insurance Company, Boston, who gave an illustrated talk on this subject from the viewpoint of the insurance engineer.

John O. Taber, Chief, Boston Fire Department, was the next speaker, and he presented the matter from his experience of many years in the fire department.

In the course of an entertaining discussion which followed, Chief Taber confided to those present why fires were so prevalent when business was poor, and told of the many activities of the fire department in the matter of preventing fires as well as of putting them out.

The meeting adjourned about 10 P.M.

J. B. BABCOCK, *Secretary.*

BOSTON, February 1, 1924. — A special meeting of the Boston Society of Civil Engineers,held this evening in the Affiliation Rooms, was called to order at 8 P.M. by the President, Frank M. Gunby.

There were 45 members present.

After stating that this special meeting had been called, in accordance with the vote passed at the January meeting of the Society, for the discussion of the recommendation of the Board of Government that the Society withdraw from the Federated American Engineering Societies, the President outlined the Society's connection with that organization during the past three years, and explained the reasons which had led the Board of Government to recommend the Society's withdrawal.

The next speaker, Col. Chas. R. Gow, the Society's representative for the past two years on American Engineering Council, stated that in his opinion the Federated American Engineering Societies was not functioning in a manner which warranted the Society's remaining a member and continuing its financial support, with the consequent hampering of our own local activities.

Following Colonel Gow's presentation of the subject there was a discussion in which the following members took part: E. S. Dorr, W. D. Henderson, S. E. Thompson, W. R. McCann, F. O. Whitney, F. A. Marston, Leonard Metcalf, F. H. Fay, D. C. Jackson and E. H. Rogers.

Governor Hartness, the newly elected president of American Engineering Council, was invited by the President to speak. After stating that he had attended the meeting to listen, and disclaiming any intention of presenting arguments on the question, owing to his having been connected with that organization for such a brief period, Governor Hartness spoke on the need of concerted action by members of the engineering profession and told of his ideals for the future of the Federation.

The motion, presented by F. A. Marston at the January meeting and laid upon the table at that time, was taken up, and after the acceptance of an amendment offered by W. D. Henderson, the following vote was passed unanimously:

> That the recommendation of the Board of Government that the Boston Society of Civil Engineers withdraw from membership in the Federated American Engineering Societies be accepted, and that the question — "Shall the Boston Society of Civil Engineers withdraw from membership in the Federated American Engineering Societies" — be submitted to the membership by letter ballot, and that this ballot be accompanied by a statement, prepared by a committee to be appointed by the President, containing sufficient information to enable the members to understand clearly the questions involved.

Meeting adjourned at 10 P.M.

J. B. BABCOCK, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

[February 15, 1924]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

Johnson, Willard Haven, Tufts College, Mass. (Age 22, b. Torrington, Conn.) 1919–20, worked as apprentice in ship construction and steel work, then as rodman at the Durant Motor Co.'s plant. Entered Tufts College in September 1920. Worked during the summers on steel construction and shop work at the Federal Shipbuilding Co., and from June, 1922, to April 15, 1923, on steel erection, assembly and dry-dock work as fitter; from April 15 to September 15, 1923, as junior engineer, Railway Division, State Board of Taxes and Assessment of New Jersey. Holds rating of Junior Engineer in New Jersey, and as Rodman, Grade A, in Massachusetts. At present a junior in civil-structural engineering at Tufts College. Refers to Robinson Abbott, W. J. Alcott, E. R. McCarthy, E. D. Mortenson, E. H. Rockwell.

Littlefield, Nathan Whitman, Jr. (Age 46, b. Ellsworth, Me.) Graduated from Brown University in 1899 with degree of C.E. 1899–1901, rodman with N. Y., N. H. & H. R.R.; 1901–02, assistant engineer, U. V. R. R. and D. L. & W. R.R., surveys and construction; 1902–05, inspector on railroad construction; 1905–07, in charge of party; 1907–12, assistant engineer on E. G. C., Worcester construction; 1912–13, assistant engineer, B. & M. R.R.; 1913 to date, assistant engineer of construction, N. Y., N. H. & H. R.R., in charge of design and construction of railroad structures and buildings, also highway and sewer work in connection with E. G. C. work. Refers to L. G. Brackett, H. L. Ripley, L. W. Tucker, A. S. Tuttle, B. T. Wheeler.

Mulvihill, Francis John, Cambridge, Mass. (Age 36, b. Philadelphia, Penn.) Graduate of Pennsylvania State College with degree of B.S. Eight and a half years as assistant to John Nolen, landscape architect, town and city planner, with the following experience: field and office work on city plans; field investigation and office work in housing; general design, plans, layout of parks and playgrounds; layout and construction plans in land subdivisions; at present assistant in the office of John Nolen, Cambridge, Mass. Refers to D. C. Jackson, W. F. Learned, J. E. Titus, J. F. Travers, Jr., G. H. Wetherbee, Jr.

Smart, Walter H., Framingham, Mass. (Age 40, b. Revere, Mass.) High School education and University Extension in sanitary science and public health, also correspondence school in bridge engineering; 1905–10, with Boston Consolidated Gas Co., drafting, surveying and designing buildings, coal pockets, wharves and tanks; 1910–13, drafting, design and appraisal work; 1914–15, drafting chemical apparatus; 1916–20, checking, designing and estimating as structural squad chief and structural inspector; 1921–22, drafting, designing and estimating houses; at present with Jackson & Moreland, designing, checking and estimating on power houses, substations and transmission towers. Refers to E. H. Cameron, W. W. Clifford, W. D. Henderson, D. S. Reynolds.

Stuart, Frank H., Newton, Mass. (Age 55, b. Newton, Mass.) A general contractor for thirty years. Refers to F. H. Fay, C. R. Gow, F. M. Gunby, C. T. Main, J. R. Worcester.

Weller, Charles, Boston, Mass. (Age 21, b. Boston, Mass.) Graduate of Harvard Engineering School, June, 1923, with degree of S.B. in civil engineering. Now senior engineering assistant in Highway Division, Massachusetts Department of Public Works. Refers to H. F. Heald, H. J. Hughes, L. J. Johnson, A. Krigger, H. F. MacWilliams, G. F. Swain.

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GILLETT, LAURENCE A.,	Asst. Engr. F. E. C. R.R., St. Augustine, Fla.
HALEY, F. WILLIAM	P. O. Box 152, Framingham, Mass.
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SMITH, MERRITT P.	431 South New St., Springfield, Ill.
WELLS, EDWARD P.	35 Orient St., Malden, Mass.
WHITNEY, FRANK O.	Hotel Vendome, Boston, Mass.

DEATH

FULLER, WILLIAM B.	June 12, 1923

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Recent Additions to the Library

U. S. Government Reports

Bureau of Yards and Docks, Annual Report of Chief of. 1923.

Commercial and Industrial Organizations of United States. 1923.

Precise Leveling in Georgia. Henry G. Avers.

U. S. Army, Chief of Engineers, Report of. Parts 1, 2 and 3. 1923.

Water Supply Papers, Nos. 502, 505, 511, 524 and 528.

State Reports

New Hampshire. Annual Report of Public Service Commissioners. 1922.

Rhode Island. Special Report of State Board of Health. 1921.

Municipal Reports

Boston, Mass. Annual Report of City Planning Board. 1922.

Lowell, Mass. Annual Report of Water Works. 1922.

Melrose, Mass. Annual Report Public Works Department. 1922.

Miscellaneous

Capital's Duty to the Wage Earner. John Calder. Gift of author.

Estimating Building Costs. Chas. F. Dingman. Gift of author.

Foundations, Abutments and Footings. Hool and Kinne.

Plan Reading and Quantity Surveying. Chas. F. Dingman. Gift of author.

Proceedings American Society for Testing Materials, Parts 1 and 2. 1923.

Structural Members and Connections. Hool and Kinne.

Transactions American Institute Mining and Metallurgical Engrs. Vol. 69.

Who's Who in Engineering.

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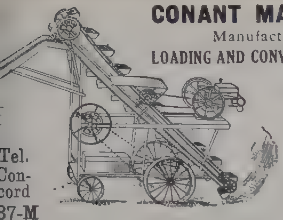

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